SANDIA NATIONAL LABORATORIES
CIVILIAN RADIOACTIVE WASTE MANAGEMENT
TECHNICAL PROCEDURE (TP)

TP-093

LOAD CELL CALIBRATION AT NEW ENGLAND RESEARCH, INC.

Revision 01

Effective Date: 10/09/03

Original Signed by Randolph J. Martin III	10/03/03
Author: Randolph J. Martin III	Date
Original Signed by Ronald H. Price	10/03/03
Technical Reviewer: Ronald H. Price	Date
Original Signed by James F. Graff	10/06/03
Quality Assurance Reviewer: James F. Graff	Date

(Reviewer signatures above document the review and resolution of comments.)

REVISION HISTORY

Revision	Description
0	Initial issue
1	TP-093 was deactivated during Audit BSC-ARC-01-010. It is now reactivated for additional work to be performed. No major technical revisions were required from the previous revision, only minor changes to the technical process, references to current procedures and other minor editorial revisions.

1.0 Scope and Objective

The objective of this Technical Procedure (TP) is to define the process for New England Research, Inc. (NER) to calibrate a load cell for use in mechanical properties experiments. This procedure is intended for implementation in a laboratory environment, in conjunction with work for the Yucca Mountain Project (YMP).

2.0 Prerequisites

Before performing work under this technical procedure, personnel must be trained by the author or the Principal Investigator (PI) and demonstrate their proficiency in performing the work in this procedure. The trainer has the responsibility for generating a record of the personnel proficiency training, as well as the responsibility that work is performed and documented in accordance with this procedure.

The personnel using this procedure are responsible for ensuring that a controlled copy of this procedure is available and used for performing the work in this procedure.

3.0 Description of Activity

Stress and strain are the two dominant parameters measured in each activity involving laboratory experiments to collect mechanical property data on intact samples. Stress is computed from the force exerted on the sample during each experiment, divided by the area of the sample over which the force is applied. The force is measured with load cells that are an integral part of the loading column. The output voltage of each load cell, along with other data, is monitored and recorded by the data acquisition system (DAS) during every experiment. It is essential to know the relationship between the output voltage of the load cell and the force.

The laboratory standard load cell at the NER laboratory will be calibrated on an annual basis by an independent calibration facility. Furthermore, at least annual calibrations of the active load cells against the standard load will ensure that correct scale factors for the force are being used during experiments.

4.0 Activity Process

The load cell calibrations are conducted in a servo-controlled hydraulic test apparatus. Where suitable (i.e., there is enough room to include the standard load cell in the loading column), the subject load cell is calibrated directly against the laboratory standard load cell. In the event the laboratory standard load cell can not be fit into the loading column, a transfer standard load cell is calibrated directly against the laboratory standard load cell, and the transfer standard is then used in the calibration of the subject load cell. The calibration procedure is essentially the same for either arrangement. In the following step-by-step procedure the “standard” load cell can be either the laboratory standard or the transfer standard. Output voltages for the standard load cell are displayed on a calibrated digital voltmeter. The voltages for the subject load cells are displayed on the DAS. All voltages are recorded from their respective displays.

4.1 Calibration Test Procedure

1. Position the standard load cell, in the loading column of a servo-controlled test apparatus, in series with the load cell to be calibrated. Properly align the load column by ensuring that the loading buttons on each transducer are coaxial.

2. With a calibrated voltmeter, measure the input voltages to both the standard load cell and the subject load cell. Record these values on the Load Cell Calibration Data Sheet (LCCDS, see Appendix A).

3. While operating the apparatus in the force feedback mode, advance the hydraulic piston until a force of approximately 350 N is applied to the loading column.

4. Continue loading the test column to a peak force of 4.5×10^5 N to seat the load column. Reduce the force on the column to zero. Record the outputs of both load cells on the LCCDS.

5. Incrementally load the test column in steps of approximately 4×10^4 N to a maximum force of 4.5×10^5 N. At each step increase in force, allow the system to equilibrate for at least one minute. Record the output voltage of both load cells on the LCCDS. At the maximum load, allow the system to equilibrate a minimum of ten (10) minutes. During this time, the output voltage of each load cell is recorded at least every sixty (60) seconds. The variation in output voltage (drift) as a function of time should not indicate a force variation of more than $\pm$ 250 N.

6. Incrementally unload the test column in steps of approximately 4×10^4 N. Record the output voltage of both load cells at each load level on the LCCDS, allowing the system to equilibrate at least one minute before taking the reading.

7. Remove the standard load cell from the test column. Return it to the test column, and repeat Steps 1 through 6. By repeating the calibration procedure, a measure of the error and reproducibility of the subject load cell is obtained. Any differences observed between the two calibration runs are likely due to variations in position and alignment of the test column.

8. Plot the calibration test results utilizing standard software. Plot the force (calculated from the recorded output voltage and the respective scale factor) measured with the standard load cell as a function of the output voltage of the subject load cell. The mean slope of the least-squares fit lines to the loading portions of these two sets of data is the scale factor (in N/V) for the subject load cell. Evaluate the results of the calibration in terms of accuracy, combined error (i.e., nonlinearity and hysteresis), and reproducibility.

    a. Accuracy: The mean deviation between the force values measured by the standard load cell and those calculated for the subject load cell using the new

scale factor. This quantity is expressed as a percentage of the full-scale output of the subject load cell.

b. Combined Error: a combination of the following two errors. This quantity is expressed as a percentage of the full-scale output of the subject load cell.

   i) Nonlinearity: The maximum difference in voltage between the calibration data and the linear fit to the data at a given force.

   ii) Hysteresis: The maximum difference between subject load cell outputs for the same applied load; the two sets of data are obtained during the loading and unloading cycles of the calibration.

c. Reproducibility: The difference in the scaling factors determined during succeeding calibration runs. This quantity is expressed as a percentage of the previous scaling factor.

9. The calibrated load cell must meet or exceed the tolerances given below:
   a. Accuracy: ± 2%
   b. Combined Error: ± 4%
   c. Reproducibility: ± 2%

   If the calibration results do not meet the specifications, the problem must be solved and an acceptable calibration performed prior to using the load cell in further experiments or system checks.

10. Complete all required information on the LCCDS.

5.0 Safety

There are no special safety hazards, only the normal hazards of the equipment. Operations will be in accordance with safety requirements of the facility where the work is being performed and that of the employer of person(s) performing the work.

6.0 Nonconformances, Deviations, and Corrective Actions

Any nonconformances or deviations must be reported to the PI as soon as possible. Deviations, deficiencies and corrective actions must be determined and documented in accordance with AP-16.1Q, *Condition Reporting and Resolution*.

7.0 QA Records

QA records, and any corrections or changes thereto, generated as a result of implementing this procedure will be prepared and submitted as inclusionary QA records (QA:QA) by the PI in accordance with AP-17.1Q, *Records Management*.

The QA records include:

- Proficiency training records (Section 2.0)

- Calibration records
- Load Cell Calibration Data Sheets (LCCDS) (Appendix A)

8.0 References

AP-16.1Q, *Condition Reporting and Resolution*
AP-17.1Q, *Records Management*

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LOAD CELL CALIBRATION DATA SHEET (LCCDS)

Unique identifier of subject load cell to be calibrated _____

Date of calibration _____ Date of last calibration _____

Calibration frequency _____

Calibration Procedure Number and Revision _____

Unique identifier of standard load cell _____Standard load cell scale factor_____

Date of last calibration of standard load cell _____

Standard Input Voltage _____ Subject Input Voltage _____

First Cycle Outputs (v)					Second Cycle Outputs (v)			
Loading		Unloading			Loading		Unloading	
Standard	Subject	Standard	Subject		Standard	Subject	Standard	Subject

Least squares fit to First Cycle:_____ Least squares fit to Second Cycle:_____

Subject load cell scale factor:_____

Calibration Results: Based on the evaluation of the accuracy, combined error and reproducibility of the data, the load cell is (check one): In Specification _____ Out of Specification _____

Attach plots of data to LCCDS (Number pages accordingly)

Note: If the load is "In Specification", the calibration is completed. If "Out of Specification", then note suspected problem(s) below and rerun the calibration.

Comments: _____

_____

Work performed by: _____

Printed Signed Date

Company/Division: _____

Location of Work: _____